Errata for third and fourth printings of
Doppler Radar and Weather Observations, Second Edition-1993

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| Page | Para. | Line | Remarks |
|---|---|---|---|
| Page | Para. | Line | Remarks: Paragraph 0 is any paragraph started on a previous page that carries over to the current page. A sequence of dots is used to indicate a logical continuation to existing words in the textbook (e.g., see errata on pp.14, 76, paragraph 3 on p. 108, etc.) |
| 14 | 2 | 2 | change to read: "…index $n = c/v$ with height (or, because the relative permeability $\mu_r$ of air is unity, on the change of relative permittivity $\varepsilon_r = \varepsilon/\varepsilon_o = n^2$ with height). |
| 30 | 2 | 9 | replace the italicized "*o*" from the first entry of the word "oscillator" with a regular "o", but italicize the "o" in the second entry of the word "*o*scillator" |
| | 3 | 7 | delete the parenthetical phrase |
| 34 | Eqs.3.2 | | replace $D$ with $D_a$ |
| 35 | 1 | 9 | at the end of the last sentence add: with origin at the scatterer. |
| | 2 | 10 | the equation on this line should read:<br>$\sigma_b = \sigma_{bm}\left(1 - \sin^2\psi / \sin^2\theta\right)^2 \cos^4[(\pi/2)\cos\theta]/\sin^4\theta$ |
| | Eq.(3.6) | | and on the line after this equation, change "$K_m$" to "$K_w$" |
| 36 | 0 | 7 | delete "$\|K_m\|^2 \equiv$" |
| | | 9 | change the end of this line to read: "Ice water has a $\|K_w\|^2 \equiv$" |
| 40 | Eq.(3.14b) | | replace subscript "m" with "w" |
| 47 | Table 3.1 | | change title to read: "The *nex*t generation *rad*ar, NEXRAD (WSR-88D), Specifications"<br>change "Beam width" to "Beamwidth"<br>change footnote *b* to read: "Initially the first several radars transmitted |

circularly polarized waves, but now all transmit linearly polarized waves". Change footnote *c* to read: "Transmitted power, antenna gain, and receiver noise power are referenced to the antenna port, and a 3 dB filter bandwidth of 0.63 MHZ is assumed.

61 Eq.(3.40b) place $\pm$ before $v_a$

0 14 last line change to "velocity limits (Chapter 7)."

68 3 8 change to read as: "or expected power $E[P(\tau_s)]$."

68-69 4 1,10,12 change "$\overline{P}(\tau_s)$" on these three lines to "$E[P(\tau_s)]$"

71 Eqs.(4.4a,b) insert $(1/\sqrt{2})$ in front of the sum sign in each of these equations

3 6 replace "p. 418" with "p. 498".

Eq. (4.6) delete the first "2"

72 0 4 change $\overline{P}(\tau_s)$ to $E[P(\tau_s)]$

2 1 change $\overline{P}(\tau_s)$ to $E[P(\tau_s)]$

3 remove footnote

73 Eq. (4.11) change "$\overline{P}(r_0)$" to "$E[P(\boldsymbol{r}_0)]$".

74-75 Eqs. (4.12), (4.14), (4.16): change "$\overline{P}(r_0)$" to "$E[P(\boldsymbol{r}_0)]$".

75 1 6 change to "$G(0)$ \$ 1"

2 18 change "$\overline{P}(r_0)$" to "$E[P(\boldsymbol{r}_0)]$".

76 Fig.4.5 change second sentence in caption to read: "The broad arrow indicates sliding of...."

82 Eq.(4.31) delete the subscript "w" on *Z*

Eq.(4.32) delete the subscript "w" on *Z*

Eq. (4.34) change "$P(\bar{r}_0)$" to "$E[P(\boldsymbol{r}_0)]$".

| | | | |
|---|---|---|---|
| | Eq. (4.35) | | change " $\overline{P}(\mathrm{mw})$ " to "$E[P(\mathrm{mw})]$ |
| | 1 | 9 | should read: ".. is the *reflectivity factor* of spheres." |
| 83 | Eq.(4.38) | | subscript "τ" should be the same size as in Eq.(4.37). |
| 84 | Eq. (4.39) | | change " $\overline{P}(r_0)$ " to "$E[P(\boldsymbol{r}_0)]$". |
| 85 | Problem 4.1 | | change " $\overline{P}$ " to "$E[P]$" in two places. |
| 108 | 1 | 1 | change "stationary" to "steady" |
| | 1 | 11 | change " $d\overline{P}$ " to "$E[dP]$". |
| | Eq. (5.42) | | change " $d\overline{P}(v)$ " to "$E[dP(v)]$ |
| | | 15 | change " $\overline{P}(\mathbf{r}_0, v)$ " to" $E[\Delta P(\mathbf{r}_0, v)]$ " |
| | Eq.(5.43) | | change " $\overline{P}(\mathbf{r}_0, v)$ " to" $E[\Delta P(\mathbf{r}_0, v)]$ " |
| | 3 | 2-3 | change to read: ".....by new ones having different spatial configurations, *the estimates* $\hat{S}(\vec{r}_o, v)$ *of* …" |
| 109 | Eq.(5.45) | | change " $\overline{P}(\mathbf{r}_0)$ " to " $E[P(\mathbf{r}_0)]$" |
| | 4 | 1 | add subscript "*I*" to $\overline{\eta}$ so it reads as " $\overline{\eta}_I(\mathbf{r}_0)$ " |
| | | 2 | delete footnote "4" at the end of this line |
| | Eq.(5.46a) | | add subscript "*I*" to $\overline{\eta}$ on the left side of this equation. |
| 113 | 1 | 1-4 | change to read: "Assume scatterer velocity is the sum of steady $v_s(\mathbf{r})$ and turbulent $v_t(\mathbf{r},t)$ wind components. Each contributes to the width of the power spectrum (even uniform wind contributes to the width because radial velocities vary across $V_6$; steady wind also brings new...." |
| | 2 | 10-18 | delete the sentences beginning with "Furthermore, we assume..." and ending with "...scatterer's axis of symmetry)." |
| | Eq. (5.59a) | | change to: |

$$
\begin{aligned}
R(mT_s) &= E[V^*(\tau_s,0)V(\tau_s,mT_s)] \\
&= E\left[\sum_i \sum_k F_i^*(0)A_i^*(0)F_k(mT_s)A_k(mT_s)\exp\{j(\phi_i - \phi_k - 4\pi v_k mT_s/\lambda\}\right] \quad (5.59a) \\
&= \sum_k E[A_k^*(0)A_k(mT_s)F_k^*(0)F_k(mT_s)\exp\{-j4\pi v_k mT_s/\lambda\}]
\end{aligned}
$$

Following this equation retype the text up to and including Eq. (5.59c) as follows:

The expectation in Eq. (5.59a) includes the ensemble of statistically stationary and homogeneous turbulent velocity fields. The expectations of the off diagonal terms of the double sum are zero because the phases ($\varphi_i - \varphi_k$) are uniformly distributed across $2\pi$; thus the double sum reduces to a single one. To simplify further analysis, assume that the weighted scatterer's cross section $F_kA_k$ is independent of $v_k$, and that $F_k$ does not change appreciably [i.e., $F_k(0) \approx F_k(mT_s)$] while the scatterer moves during the time $mT_s$. Furthermore, assume $A_k$ varies randomly in time (i.e., a hydrometeor may oscillate or change its orientation relative to the electric field). Thus Eq. (5.59a) reduces to

$$R(mT_s) = \sum_k R_k(mT_s)|F_k|^2\; E[e^{-j4\pi v_k mT_s/\lambda}] \qquad (5.59b)$$

where

$$R_k(mT_s) = E[A_k^*(0)A_k(mT_s)].$$

Because $R(0)$ is proportional to the expected power E[$P$], and because

$$E[P(\boldsymbol{r}_0)] = \sum_k \sigma_{bk} I(\boldsymbol{r}_0, \boldsymbol{r}_k) \qquad (5.59c)$$

114 2 2-4 modify to read: "...mechanisms in Eq. (5.59b) act through product terms. Furthermore, the $k$th scatterer's radial velocity $v_k$ can be expressed as the sum of the velocities due to steady and turbulent winds that move the scatterer from one range position..."

6-13 delete these lines and replace with:

"Eq. (5.59b), the velocities $v_s(\boldsymbol{r})$ and $v_t(\boldsymbol{r}, t)$ associated with steady and turbulent winds can each be placed into separate exponential functions that multiply one another. Thus the expectation of the product can be expressed by the product of the exponential containing $v_s(\boldsymbol{r})$ and the expectation of the exponential function containing $v_t(\boldsymbol{r}, t)$. The Fourier transform of $R(mT_s)$, giving the composite spectrum $S(f)$, can then be expressed as a convolution of the spectra associated with each of the three functions of lag $mT_s$."

115 Eq. (5.60) add a hat above “$S$” to read as “$\hat{S}$” in the three places it appears.

3 1 “R” in “$\mathrm{R_k}$” should be italicized to read “$R_{\mathrm{k}}$”

9 change “Eq. (5.59a)” to “Eq. (5.59b)”

14-15 Change these lines and Eq. (5.64) to read: “Because the correlation coefficient is related to the normalized power spectrum through Eq. (5.19), and because the Doppler shift $f = -2v/\lambda$, $\rho(mT_s)$ can be expressed as

$$\rho(mT_s) = \int_{-\lambda/4T_s}^{\lambda/4T_s} \frac{2}{\lambda} E[\hat{S}_n^{(f)}(-2v/\lambda)] e^{-j4\pi v m T_s/\lambda} dv$$

$$= \int_{-v_a}^{v_a} E[\hat{S}_n(v)] e^{-j4\pi v m T_s/\lambda} dv, \tag{5.64}$$

116 0 1-4 change these lines to read: where $S_n^{(f)}(-2v/\lambda)$ is the normalized power spectrum in the frequency domain folded about zero, $S_n(v)$ is the normalized power spectrum in the Doppler velocity domain, and the two power spectra are related as

$$S(v) = \frac{2}{\lambda} S^{(f)}(-2v/\lambda). \tag{5.65}$$

By equating Eq. (5.63) to Eq. (5.64), and assuming all power is confined to the Nyquist limits, $\pm v_a$, it can be concluded that

$$p(v) = E[\hat{S}_n(v)] \ . \tag{5.66}$$

116 1 1-3 change to read: “Thus, for homogeneous turbulence, at least homogeneous throughout the resolution volume $V_6$, the *expected* normalized power spectrum is equal to the velocity probability distribution. Moreover, it is independent of reflectivity and the angular and range weighting functions.

1 3-7 Delete the last two sentences beginning with “Although, in deriving….”

2 19 change to read: “where $\sigma_s^2$ is due to shear of steady wind $v_{\mathrm{s}}$, $\sigma_\alpha^2$ to..”

117 2 4-7 Modify these lines to read: “where the terms are due to shear of $v_{\mathrm{s}}$ along the three spherical coordinates at $\mathbf{r}_0$. In this coordinate system (5.70) automatically includes..”

9 change to read: “the so-called beam-broadening term;....”

3 Replace the text in this paragraph up to and including Eq. (5.75) with:

"Spherical coordinate shears of $v_s$ can be directly measured with the radar and it is natural to express $\sigma_s^2$ in terms of these shears. If the resolution volume $V_6$ dimensions are much smaller than its range $r_0$, and angular and radial shears are uniform, $v_s$ within $V_6$ can be expressed as

$$v_s - v_0 \approx k_\varphi r_0 \sin\theta_0(\varphi - \varphi_0) + k_\theta r_0(\theta - \theta_0) + k_r(r - r_0) \tag{5.71}$$

provided $\theta_1$<<1 (radian) and $\theta_0 >> \theta_1$, where

$$k_\varphi \equiv \frac{1}{r_o \sin\theta_0}\frac{\partial v_s}{\partial\varphi}, \quad k_\theta \equiv \frac{1}{r_o}\frac{\partial v_s}{\partial\theta}, \quad k_r \equiv \frac{\partial v_s}{\partial r} \tag{5.72}$$

are angular and radial shears of $v_s$. Angular shears are present even if Cartesian shears are non-existent, and are functions of $\mathbf{r}_0$. For example, if wind is uniform (i.e., constant Cartesian components $u_0$, $v_0$, $w_0$),

$$\frac{\partial v_s}{\partial\phi} = (u_0\cos\phi_0 - v_0\sin\phi_0)\sin\theta_0; \quad \frac{\partial v_s}{\partial\theta} = w_0\sin\theta_0 - (u_0\sin\phi_0 + v_0\cos\phi_0)\cos\theta_0; \quad k_r = 0\,. \tag{5.73}$$

If reflectivity is uniform and the weighting function is product separable and symmetric about $\mathbf{r}_0$, substitution of Eq. (5.71) into Eq. (5.51) produces

$$\sigma_s^2(\boldsymbol{r}_0) = \sigma_{s\theta}^2 + \sigma_{s\phi}^2 + \sigma_r^2 = k_\theta^2 r_0^2\sigma_\theta^2 + k_\phi^2 r_0^2\sin^2\theta_0\sigma_\phi^2(\theta_0) + k_r^2\sigma_r^2\,. \tag{5.74}$$

Because lines of constant $\phi$ converge at the vertical, the second central moment $\sigma_\phi^2(\theta_0)$ of the two-way power pattern is $\sigma_\phi(\theta_0) = \sigma_\phi(0)/\sin\theta_0$, where $\sigma_\phi(0)$ is the intrinsic beamwidth; $\sigma_r^2$ is the second central moment of $|W(r)|^2$. For circularly symmetric Gaussian patterns,

$$\sigma_\theta = \frac{\theta_1}{4\sqrt{\ln 2}}\,; \quad \sigma_\phi(\theta_0) = \frac{\theta_1}{4\sqrt{\ln 2}}\frac{1}{\sin\theta_0} \tag{5.75}$$

125 1 1 replace "average" with "expected"

Eq. (6.5) append to this equation the footnote: "In chapter 5 D is the complex correlation coefficient. Henceforth it represents the magnitude of this complex function."

4 5 remove the overbar on $P$, $S$, and $N$

| | | | |
|---|---|---|---|
| 126 | 0 | 1 | change to read: “power estimate $\hat{P}$ is reduced……variance of the $P_k$..” |
| | 3 | 2-4 | the second sentence, modified to read, "The $P_k$ values of meteorological interest...meeting this large dynamic range requirement", should be moved to the end of the paragraph 1 |
| | | 5 | change " $\overline{P}$ " to " $S$ ". |
| 127 | 0 | 1-2 | remove the overbar on $P$ in the three places |
| | 3 | 1 | remove the overbar on $Q$ |
| | | 8 | delete the citation “(Papoulis, 1965)” |
| 128 | 1 | 8 | change “unambiguous” to “Nyquist” |
| | 2 | 4-7 | rewrite the three sentences after Eq. (6.12) as: “For large $M$ and $\sigma_{vn} << 1$, $M_I = 2M\sigma_{vn}\pi^{1/2}$. The variance of $S$ estimated from $M$ samples is calculated using the distribution given by Eq. (4.7) in which $S \equiv P$ (this gives, in Eq. (6.10), $\sigma_Q^2 = S^2$), and calculating $M_I$ from Eq. (6.12). Thus the standard deviation of a M-sample signal power estimate is $S/\sqrt{M_I}$.” |
| | 3 | 1-2 | change to read “To estimate $S$ in presence of receiver noise, we need to subtract.....” |
| 129 | 0 | 5-6 | change last sentence to read: ....then the number of independent samples can be determined using an analysis similar to..... |
| 130 | Table 6.1 | | add above **“Reflectivity factor calculator”** the new entry “**Sampling rate”,** and in the right column on the same line insert “0.6 MHz". Under "**Reflectivity factor calculator**", "Range increment" should be “0.25 km” and not “1 or 2 km”. But insert as the final entry under "**Reflectivity factor calculator**" the entry “Range interval )r”, and on the same line insert “1 or 2 km” in the right column. |
| 136 | footnote | | change to read: To avoid occurrence of negative $\hat{S}$, only the sum in Eq. (6.28) is used but it is multiplied with $S\hat{N}R/(S\hat{N}R + 1)$ |
| 137 | 2 | 1 | delete “( $\sigma_{vn} > 1/2\pi$ )” |
| 155 | 3 | 3 | in section 6.8.5 line 3, change “Because” to “If” |

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|---|---|---|---|
| 160 | 2 | 6 | change “unambiguous velocity ” to “Nyquist velocity” |
| 171 | 0 | 3 | $T_s$ should be $T_2$ |
| 173 | 0 | 1 | change to read: “…velocity interval $\pm v_m$ for this….” |
| | Eq. (7.6b) | | place $\pm$ before $v_m$ |
| | 3 | 9-11 | change “unambiguous” to “Nyquist” at two places, and change “An unambiguous velocity” to “A Nyquist interval” |
| 182 | Eq.(7.12) | | $W_iW_{i+1}$ should be $W_iW_{i+l}$ |
| 197 | 1 | 1 | “though” should be “through” |
| | 2 | 4 | “Fig.3.3" should be “Fig.3.2" |
| 200 | Fig.7.28 | | Note the dashed lines are incorrectly drawn; they should extend from -26 dB at "$2^o$ to -38dB at "$10^o$, and then the constant level should be at -42 dB. |
| 201 | 0 | 2 | “Norma” should be “Norman” |
| 222 | Eq. (8.18) | | the differential “d$D$” on the left side of Eq.(8.18) must be moved to the end of this equation. |
| 228 | 1 | 4 | change $Z_w$ to $Z_e$ |
| | Eq.(8.24) | | this equation should read as: |

$$Z_i = (|K_w|^2/|K_i|^2)Z_e \qquad (8.24)$$

| | | | |
|---|---|---|---|
| | 2 | 6 | change to: ....to estimate the equivalent rainfall rate $R_s$ (mm/hr) from the... |
| | | 7 | delete “with $Z_w = Z_e$” |
| 232 | 0 | 10-11 | change to: ...microwave (8 = 0.84 cm) path.... |
| 234 | Eq.(8.30) | | right bracket “}” should be matched in size to left bracket “{” |
| 248 | Eq.(8.57) | | parenthesis “)” needs to be placed to the right of the term “(b/a” |
| 249 | Eq.8.58 | | $\cos^2$ * should be $\sin^2$ *; replace $k_o$ with $k$; $p_v$ and $p_h$ should be replaced |

| | | | |
|---|---|---|---|
| | | | with $p_a$ and $p_b$ respectively |
| | Eq.8.59a,b | | change the subscripts "h" to "b", and "v" to "a" |
| | 2 | 9 | change to read: $p_a$ and $p_b$ are the drop's susceptibility in generating dipole moments along its axis of symmetry and in the plane perpendicular to it respectively, and $e$ its eccentricity, |
| | | 12-13 | rewrite as: ...symmetry axis, and $R$ is the apparent canting angle (i.e., the angle between the electric field direction for "vertically" polarized waves (**v** in Fig.8.15) and the projection of the axis of symmetry onto the plane of polarization. The forward........ |
| | | 17 | modify to read: $f_h = k^2 p_b$, and $f_v = k^2\ [(p_a - p_b)\sin^2 * + p_b]$ (Oguchi, ....... |
| | 3 | 4-5 | Rewrite as: Hence from Eqs.(8.58) an oblate drop has, for horizontal propagation and an apparent canting angle equal to zero, the following cross sections for h and v polarizations: |
| 268 | Fig. 8.29 | | $LDR_{hv}$ on the ordinate axis should be $LDR_{vh}$ |
| | 0 | 1,4 | change $LDR_{hv}$ to $LDR_{vh}$ at the two places it appears in this paragraph. |
| 269 | Fig. 8.30 | | In the caption, change $LDR_{hv}$ to $LDR_{vh}$ at the two places it appears. |
| 277 | 0 | 16 | change "23000" to "230,000" |
| 289 | 2 | 3 | delete the sentence beginning with "In this chapter overbars…." |
| 298 | Fig.9.4a,b | | here and elsewhere in the text, remove periods in time abbreviations (i.e., should be: "CST", not C.S.T.") |
| 390 | 0 | 1 | change to read "along the path R of the aircraft, and $S_{ij}(K_R)$ is the Fourier transform of $R_{ij}(R)$. In contrast...." |
| 393 | 1 | 11 | the subscripts on $R_{11}(0)$ should be changed to $R_{ll}(0)$; (i.e., so that it is the same as the subscripts on the second "$D$ " in line 19). |
| | Eq. (10.33) | | place subscript $l$ on $C$ so that it reads $C_l$. |
| 394 | 0 | 1 | change to read: "where $C_l^2$ is a dimensionless parameter with a value of about 2. |
| | Eq.(10.37) | | change to read: |

$$R_{ii}(\rho, \tau_1 = 0) = R(0)[1 - (\rho / \rho_{oi})^{2/3}] \qquad (10.37)$$

| | | | |
|---|---|---|---|
| 398 | 1 | 12 | change to read: "…of the weighting function $I_n$, and $\Phi_v(\mathbf{K})$ is the spectrum of point velocities." |
| 404 | 4 | 7 | place an over bar on the subscript "u" in the next to last equation |
| 412 | 2 | 5 | change "polynomial surface" to "polynomial model" |
| | | 7 | change "surface" to "model" |
| 419 | Fig. 10.18 | | the "-5/3" dashed line drawn on this figure needs to have a -5/3 slope. Furthermore, remove the negative sign on "s" in the units (i.e., $m^3/s^{-2}$) on the ordinate scale; this should read ($m^3/s^2$). |
| 445 | 1 | 6 | delete "time dependence of the" |
| 453 | 1 | 10 | delete "(s)" from "scatterer(s)"; subscript "c" in $D_{c,\|\|}$ should be replaced with subscript "B" to read $D_{B,\|\|}$ |
| | | 12 | a missing subscript on $\rho_{,\perp}$ should be subscript "B" so the term reads: $\rho_{B,\perp}$ |
| Eqs. (11.105, &106) | | | the symbols $\|\|$ & $\perp$ should also be subscripts, along with "B", on the symbol "$\rho$" to read "$\rho_{B,\|}$" and "$\rho_{B,\perp}$". |
| 454 | 0 | 6 | change "blob" and "blobs" to "Bragg scatterer" and "Bragg scatterers" |
| | Fig.11.11 | | caption should be changed to read: "........, a receiver, and an elemental scattering volume $dV_c$." |
| 456 Eq. (11.115) | | | bold "r" in the factor $W(\mathbf{r})$ needs to be unbolded |
| | Fig. 11.12 | | add a unit vector $\mathbf{a}_o$ drawn from the origin "**O**" along the line "$r_0$". |
| 458 | 2 | 4 | make a footnote after $\sqrt{2}$ to read: z' is the projection of r' onto the z axis; not to be confused with z' in Fig.11.12 which is the vertical of the rotated coordinate system used in section 11.5.4. |
| 459 | Eq.(11.125) | | delete the subscript "c" in this equation, as well as that attached to $\rho_{ch}$ in the second line following Eq.(11.125) so that it reads "$\rho_h$". |

| | | | |
|---|---|---|---|
| 460 | 1 | 4-9 | delete the third to fifth sentences in this paragraph and replace with the following:<br>Condition (11.124) is more restrictive than (11.106); if (11.124) is violated the Fresnel term is required to account for the quadratic phase distribution *across the scattering volume*, whereas (11.106) imposes phase uniformity *across the Bragg scatterer*; this latter condition is more easily satisfied the farther the scatterers are in the far field (also see comments at the end of section 11.5.3). |
| 464 Fig. 11.14 | | | caption: the first citation is incorrect. It should read: "(data are from Röttger et al., 1981)". Furthermore, delete the last parenthetical expression: "(Reprinted with permission from ….)." |
| 468 | 2 | 11 | change "(11.109)" to "11.104" |
| 478 | 0 | 7 | Change to read:<br>"...the gain g. Then g, now the directional gain (Section 3.1.2), is related..." |
| 493 | 1 | | delete the last sentence and make the following changes:<br><br>1) change lines 2 and 3 to read: "... $C_n^2 = 10^{-18}$ m$^{-2/3}$ (Fig.11.17), the maximum altitude to which wind can be measured is computed from Eq.(11.152) to be about 4.5 km.<br><br>2) change lines 4 and 5 to read: "that velocity estimates are made with SNR = -19.2 dB (from Eq.11.153 for $T_s = 3.13\text{x}10^{-3}$ s), and that $F_v$ = 0.5m s$^{-1}$, SD(v) =1 m s$^{-1}$, and a system temperature is about 200 K (section 11.6.3)." |
| | 2 | 1-4 | change to read: "Assuming that velocities could be estimated at SNRs as low as -35dB (May and Strauch, 1989), the WSR-88D could provide profiles of winds with an accuracy of about 1 m s$^{-1}$ within the entire troposphere if $C_n^2$ values…" |
| | | 8 | change "14" to "12" |
| | | 9 | change "able to measure" to "capable of measuring" |

**The following supplement contains updates and should clarify or enhance the text at the indicated places:**

33 1 4 change to read: …and often its intensity (i.e., power density) versus…

34 0 It might be of interest to note that the one-way radiation pattern of the WSR-88D radar (the network radar used by the Weather Service in the USA) can be approximated with

$$f^2(\theta) = \left( \frac{48.2 J_3(u)}{u^3} + \frac{0.32 J_1(u)}{u} \right)^2 / (1.16)^2$$

which agrees to within 2 dB of the measured pattern down to about the -20 dB level. The pattern given by this equation is slightly broader than that measured for NSSL's research WSR-88D at a wavelength of 0.111m (i.e., the 3 dB beamwidth calculates to about $1^o$ whereas the measured width is about $0.93^o$). This analytical expression is that obtained if the reflector's aperture is illuminated with a power density $[1\text{-}4(\rho/D_a)^2]^4$ on a uniform illumination level producing at the reflector's edge a power density 17.2 dB below the peak. Sidelobe levels, calculated from the above expression for angles from about $3^o$ to $10^o$ from the beam axis, are about 60 dB below the peak lobe. Measured sidelobe levels, however, can be anywhere from a few dB to about 20 dB larger than this level. The increased levels are due to blockage by the feed, its supporting spars, and the radome.

35 1 There are several definitions of cross sections. For example, $\sigma_d = \frac{S_r}{S_i} r^2$ is the *differential scatter cross section*; that is, it is the cross section *per unit* solid angle. Integration of $\sigma(\theta', \phi')$ over 4π steradians gives the *total scatter cross section* (see section 3.3).

36 0 2 Insert at the end of the first sentence: "It can be shown, using formulas presented in Section 8.5.2.4, that Eq. (3.6) has practical validity only if drops have an equivalent spherical diameter $D_e$ less than 2 mm. Drops having $D_e$ larger than 2 mm have backscatter cross sections differences larger than about 0.5 dB for horizontally and vertically polarized waves (i.e., $\sigma_h > 1.1\sigma_v$)."

44 3 4 Blake has more recently published (1986, in "Radar range performance analysis", 2nd ed., ARTECH House, Norwood, MA.) new values of attenuation in gases. For example, at 8 = 10 cm, $r$ = 200 km, $2_e = 0^o$, the two way loss is about 0.3 dB larger than that given in Fig.3.6.

56 If the beam is passing through clouds and storms, Eq. (3.34) should be replaced by

$$T_s' = \left(1 - \frac{1}{\ell_c}\right)(1 - \chi + \chi\eta_r)T_c + \frac{1-\chi}{\ell_c}T_s + \chi(1-\eta_r)T_g + \frac{\chi\eta_r}{\ell_c}T_s$$

where $\ell_c$ and $T_c$ are the cloud's attenuation and temperature.

57 Fig. 3.11 For completeness, the ordinate should be labeled "Sky noise temperature $T_s$ (K)"

71 2,3 An explanation for the √2 factors in Eqs. (4.4) and (4.6) and how power is related to $\sigma^2$ might be helpful. Because a lossless receiver is assumed, the sum of powers in the *I* and *Q* channels must equal the power at the input to the receiver (i.e., the synchronous detectors in Fig. 3.1). Because we have assumed the amplitude of the echo voltage at the receiver's input is *A* (e.g., Eq. (2.2b)), the amplitude of the signal in the *I* and *Q* channels must be $A/\sqrt{2}$. Furthermore, we can determine from Eq. (4.5) that the rms values of the *I* and *Q* voltages equals σ (i.e., $I_{\text{rms}} = Q_{\text{rms}} = \sigma$). Thus the average power in each of the channels is $\sigma^2$, and the sum of the average powers in these two channels is 2 $\sigma^2$ which equals the expected power E[P] at the input to the receivers. The constants of proportionality (i.e., impedances) that relate voltage to power are assumed the same at all points in the receiver (e.g., at inputs to the *I* and *Q* channels).

82 Because there is considerable confusion concerning the use of the unit dBZ, and because some writers use dBz for the decibel unit of reflectivity factor *Z*, we present the following comment:

The logarithm decibel dB is not an SI unit. On the other hand, the dB has been accepted widely as the symbol of the decibel as a "unit" (e.g., The International Dictionary of Physics and Electronics, D. Van Nostrand Co. Inc., 1961, 1355 pp). Furthermore, according to SI rules, units should not be modified by the attachment of a qualifier. Nevertheless, appendages to dB have been accepted in the engineering field to refer the dB unit to a reference level of the parameter being measured; e.g., dBm is the decibel unit for 10 $\log_{10}$ P where P is the power referenced to 1 milliwatt (e.g., Reference Data for Radio Engineers, 5th Edition, p.3-3). dBZ has been accepted by the AMS as the symbol for the "unit" decibel of reflectivity factor referred to 1 $\text{mm}^6\text{m}^{-3}$ (Bulletin, 1987, p.38).

1 at the end of this paragraph add: "If scatterers are not *liquid* water spheres, $Z_e$ will also account for the difference in the refractive index of water and that of the scatterers (e.g., ice)."

*Because we hardly ever know the composition of the scatterers, even if we know they satisfy the Rayleigh approximation, the added sentence tells the reader that the radar equation always is written with the parameter* $|K_w|$, *and not a generic parameter (e.g.,* $|K|$ *).*

*Furthermore, if scatterers happen to be, for example, ice spheres, the equivalent reflectivity factor $Z_e$ will account for our lack of knowledge of the scatterers' composition.*

110 at the end of section 5.2, add the following paragraph:
In this section we assumed scatterers follow exactly the air motion. But usually scatterers are hydrometeors that fall in air, have different fall speeds because of their different sizes, and change orientation, and vibrate (if they are liquid). These hydrometeor characteristics broaden the Doppler spectrum associated with the velocity field increasing $\sigma_v^2(\vec{r}_o)$ obtained from Eq. (5.51).

114 2 at the end of this modified paragraph (i.e., see errata) add: "Thus the variance (i.e., the square of the spectrum width) associated with the spectral broadening mechanism due to turbulence can be added to the variances associated with the spectral broadening mechanism due to the steady wind and drop oscillations. Furthermore, steady wind can be expressed as a power series in terms of the displacement of the scatterers from the center of the resolution volume (Section 5.3). Thus the zeroth order term is the radial component of the steady wind *at the resolution volume center*, the first order term gives the spatial dependence of the radial wind due to uniform radial velocity shear (note that uniform wind, uniform in a Cartesian coordinate system, generates radial velocity shear because of the finiteness in the angular width of the beam—Section 5.3), etc. Each term of the power series is part of the sum of velocities in the exponent of Eq. (5.59b), and thus the transform of Eq. (5.59b) can be expressed as a convolution of the spectrum associated with each component of the steady wind. Because the resultant spectrum is a convolution of the spectra associated with each of the mechanisms (i.e., turbulence, shear, etc.) that cause a change of velocity across the resolution volume, the variance (i.e., spectrum width squared) of the resultant spectrum is the sum of the variances associated with the spectra of each mechanism.

118 0 after Eq. (5.75) it should be noted that as $\theta_0 \rightarrow 0$, the angular shears in Eq. (5.74) should be replaced by $k_\theta$ along the two principal axes of the beam pattern. For example, if the beam is circular symmetric and $\theta_0 = 0$, $\sigma_s^2 = r_o^2\sigma_\theta^2[k_\theta^2(\phi = 0) + k_\theta^2(\phi = \pi/2)] + (\sigma_r k_r)^2$.

After Eq. (5.76): It should be noted that if the receiver bandwidth $B_6$ is much larger than the reciprocal of the pulse width $\tau$, not an unusual condition, $\sigma_r^2 = \frac{1}{12}\left(\frac{c\tau}{2}\right)^2$.

128, Eq.(6.12): this equation and the discussion that follows it, is valid when signal power is much stronger than noise power. The following text gives the standard deviation of the Logarithm of *Z*(dBZ) estimates as a function of Signal-to-Noise ratio. This text could replace paragraph 3 on p.128.

To estimate *Z* in presence of receiver noise, we need to subtract receiver noise power *N* from the signal plus noise power estimate $\hat{P}$. Thus the reflectivity estimate is $\hat{Z} = \alpha\hat{S} = \alpha(\hat{P} - N)$ where $\hat{P}$ is a uniformly weighted *M* sample average estimate of the power *P* at the output of the square law receiver (as in the WSR-88D), *N* is the receiver noise power, and " is a constant calculated from the radar equation. Because *N* is usually measured during calibration, many more samples are used to obtain its estimate. Therefore its variance is negligibly small, and the noise power estimate can safely be replaced with its expected value *N*. *Z* is usually expressed in decibel units; that is, $\hat{Z}(dBZ) = 10\log_{10}\hat{Z} = 10\log_{10}(\alpha\hat{S})$ where $\hat{Z}$ is expressed in units of mm$^6$ m$^{-3}$. The error in decibel units is now derived. Let $\hat{S}$, the *M* sample estimate of signal power, be expressed as $\hat{S} = S + \delta S$ where $\delta S$ is the displacement of $\hat{S}$ from *S*. Thus

$$\hat{Z}(dBZ) = 10\log_{10}(\alpha S) + 10\log_{10}\left(1 + \frac{\delta S}{S}\right) = Z + \delta Z(dBZ) \qquad (6.13a)$$

For sufficiently larger *M*, $\delta S / S$ is small compared to 1, and hence the second term can be expanded in a Taylor series. Retaining the dominant term of the series, the estimated reflectivity is well approximated by

$$\hat{Z}(dBZ) \approx Z + 4.34\left(\frac{\hat{S}}{S} + 1\right). \qquad (6.13b)$$

Because the first term and the constant 4.34 are not random, the standard error in the estimate is simply $S.D.[\hat{Z}(dBZ)] = 4.34\, S.D.[\hat{S} / S]$. Because $\hat{S} = \hat{P} - N$ where *N* is a known constant (for a correctly calibrated radar), $S.D.[\hat{S}] = S.D.[\hat{P}] = P / \sqrt{M_I} = (S + N) / \sqrt{M_I}$, where $M_I$ is the number of independent signal plus noise power samples. Hence

$$S.D.[\hat{Z}(dBZ)] = \frac{4.34(S + N)}{S\sqrt{M_I}} \qquad (6.13c)$$

The number of independent samples $M_I$ that are contained in the *M* sample set, can be calculated from (6.12) in which $\rho_s(mT_s)$ is replaced by $\rho_{s+n}(mT_s)$ the magnitude of the correlation coefficient of the signal plus noise samples.

Using (6.4), the correlation of signal plus noise for a Gaussian shaped signal spectrum and a white noise spectrum, normalizing it by $S + N$ to obtain the correlation *coefficient* of the signal plus power estimates, the correlation coefficient at the output of the square law receiver, can be written as

$$\rho_{s+n}(mT_s) = \left( \frac{S}{S+N} \exp\{-2(\sigma_{vn}\pi m)^2\} + \frac{N}{S+N}\delta_m \right)^2 \qquad (6.13d)$$

Under the condition that $\sigma_{vn} >> M^{-1}$, (i.e., the spacing between spectral lines is much smaller than the width of the spectrum), the sum in (6.12) can be replaced by an integral. Furthermore, if $M$ is large so that $\rho_{s+n}(mT_s)$ is negligibly small at $MT_s$, the limits on the integral can be extended to infinity. Evaluation of this integral under these conditions yields

$$M_I = \frac{\left(1 + \frac{S}{N}\right)^2 M}{1 + 2\frac{S}{N} + \frac{(S/N)^2}{2\sigma_{vn}\sqrt{\pi}}} \qquad (6.13e)$$

The formula for calculating the standard error in estimating $Z$(dB$Z$) as a function of $S/N$ is obtained by substituting (6.13e) into (6.13c) yielding

$$S.D.[\hat{Z}(dBZ)] = \frac{4.34}{\sqrt{M_I}} \frac{N}{S} \left( 1 + 2\frac{S}{N} + \frac{(S/N)^2}{2\sigma_{vn}\sqrt{\pi}} \right)^{1/2} dB \qquad (6.13f)$$

136 4 1-5 The form of Eq.(6.29) was first presented by Rummler (1968). *But this form does not follow directly from Eq.(6.27) as in stated in the sentences preceding Eq.(6.29)*. Thus it would be more proper to change these lines to read:

"If spectra are not Gaussian, Rummler (1968) has derived an estimator valid for small spectrum widths (i.e., $\sigma_{vn} << 1$). This estimator is

(6.29)

At large widths Eq. (6.29) has an asymptotic (M 6 INF ) negative bias which causes an underestimate of the true spectrum width (Zrnif, 1977b), whereas ....... spectrum is Gaussian)"

Added Reference:

Rummler, W. D. (1968), Introduction of a New Estimator for Velocity Spectral Parameters. *Technical Memorandum, April 3, 1968.* Bell Laboratories, Whippany, New Jersey 07981.

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| 195-196 | | | Because we use the terms effective pattern and effective beamwidth, use of the subscript "e" instead of "a" on $f_a(\varphi-\varphi_0)$ and on $\varphi_a$ would be more natural. |
| 255 | 1 | 2 | Recent data from a disdrometer show as much as a factor of 3 error |
| 391 | 0 | 2 | it should be noted that the correlation scale $\rho_0$ is not the same as the integral scale $\rho_I$ which is defined as |

$$\rho_I = \int_0^\infty \frac{R(\rho)}{R(0)} d\rho$$

For the correlation function given by Eq. (10.19), $\rho_0$ is related to $\rho_I$ as

$$\rho_I = \frac{\Gamma(v+0.5)\Gamma(0.5)}{\Gamma(v)} \rho_0$$

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|---|---|---|---|
| 398 | | | Section 10.2.1: we introduce the parameter $M_v(\mathbf{K})$ in Eq.(10.46) but define it later in Eq.(10.46). We should place Eq.(10.48), but label it (10.46), before Eq.(10.46) that now become Eq.(10.47). Other adjustments should be made to correct equation numbers; these should be few. |
| 403 | 1 | 6 | For a more detailed explanation of the steps in Section 10.2.2, we offer the following revision of section 10.2.2: |

In this section we define the relationship between the variance of velocities at a point and the expected spectrum width (Rogers and Tripp, 1964). Let the variance of the velocity $v(\boldsymbol{r}, t)$ at a point be $\sigma_p^2$. This variance is defined by the following equation

$$\sigma_p^2(\boldsymbol{r}) = < v^2(\boldsymbol{r},t) > - < v(\boldsymbol{r},t) >^2 \qquad (10.55)$$

where the brackets indicate ensemble (or time) averages. We now assume that steady wind is not present, or that it can be determined and was removed. In this case only turbulence is present and it is a random vector field having a zero mean (i.e., $<v(\boldsymbol{r}, t)> = 0$).

The Doppler spectrum width due to turbulence can be obtained from Eq. (5.51). Although Eq. (5.51) was derived under the assumption that $v(\boldsymbol{r}, t)$ is steady, this equation can be applied to a time varying wind such as produced by turbulence. But then $\sigma_v^2$ would be a time varying quantity because $v(\boldsymbol{r}, t)$ is a time dependent variable. Thus, from Eq. (5.51) we obtain (for turbulence $\sigma_v^2 \to \sigma_t^2$),

$$\sigma_t^2(t) = \overline{[v^2(\boldsymbol{r},t)]} - \left[\overline{v(\boldsymbol{r},t)}\right]^2 . \qquad (10.56)$$

where the *overbar* denotes a spatial average of turbulent velocities weighted by $I_n(\mathbf{r}_0,\mathbf{r})\eta(\mathbf{r})$. Because a spatial average has been performed, $\sigma_t^2(t)$ is not a function of the argument '$\boldsymbol{r}$', but of $\boldsymbol{r}_0$ and $t$. We have dropped the argument $\boldsymbol{r}_0$ to simplify the notation and because further discussion is restricted to $V_6$ at the fixed location $\boldsymbol{r}_0$. Nevertheless, the argument $\boldsymbol{r}_0$ is implicit in $\sigma_t^2(t)$. Because turbulent velocity is a random variable, so is $\sigma_t^2(t)$. Usually we are not interested in the time dependence of $\sigma_t^2(t)$, but in its statistical properties such as its mean or expected value, $<\sigma_t^2(t)>$, its auto-correlation, etc. We shall show how the expected value of $\sigma_t^2(t)$ is related to the expected value of the radar estimates of $\sigma_t^2(t)$. We shall also relate $<\sigma_t^2(t)>$ to the energy density $E$ of turbulence.

The variance of the spatially weighted Doppler (i.e., radial) velocity $\overline{v(\boldsymbol{r},t)}$ is, by definition, given by

$$\mathrm{var}[\overline{v(\boldsymbol{r},t)}] \equiv <\overline{(v(\boldsymbol{r},t))}^2> - <\overline{v(\boldsymbol{r},t)}>^2 \equiv \sigma_{\bar{v}}^2. \tag{10.57}$$

$\overline{v(\boldsymbol{r},t)}$ is the mean Doppler velocity that could be calculated, for example as in the WSR-88D processor, using the pulse pair algorithm (Section 6.4.1). This calculation would give a radar estimated $\overline{v(\boldsymbol{r},t)}$. It is to be noted that although $\overline{v(\boldsymbol{r},t)}$ is a time varying quantity, its variance $\sigma_{\bar{v}}^2$ is not under the condition that turbulence is statistically stationary as will be assumed herein.

It should also be noted that $\sigma_{\bar{v}}^2$ does not include the variance associated with the statistical uncertainty in the radar *estimates* of $\overline{v(\boldsymbol{r},t)}$. That is, in addition to the variance of $\overline{v(\boldsymbol{r},t)}$ due to the time changing velocity field, we have additional variance associated with the random location of scatterers (i.e., the time dependence of $\overline{v(\boldsymbol{r},t)}$ differs from the time dependence of the $\overline{v(\boldsymbol{r},t)}$ estimates). For example, even if $v(\boldsymbol{r}, t)$ was a constant independent of time, and therefore $\overline{v(\boldsymbol{r},t)}$ would be a constant, the estimates of $\overline{v(\boldsymbol{r},t)}$ would be random due to the fact that scatterers can have different locations for the same velocity field; each configuration of scatterers would produce a different radar estimate of $\overline{v(\boldsymbol{r},t)}$.

To illustrate, assume a constant wind that carries scatterers perpendicularly across the beam. In this case $v(\boldsymbol{r},t) = v(\boldsymbol{r}) = 0$, and $\overline{v(\boldsymbol{r})}$ = constant = $c$ = 0. Nevertheless, estimates $\hat{c}$ of $\overline{v(\boldsymbol{r})}$ are time varying and random because $\overline{v(\boldsymbol{r})}$ is estimated from weather signals which are randomly varying. That is, although $\overline{v(\boldsymbol{r})}$ = 0, the Inphase, $I$, and Quadrature phase, $Q$, components of the weather signal are still Gaussian distributed random variables as shown in Fig. 4.4. The time sequence of the $I$, $Q$ samples will randomly progress in the $I$, $Q$ plane. But in this case there is no mean rotation about the origin (contrary to that suggested by Fig. 4.4) because the mean Doppler velocity is zero. Although the progression of the $I,Q$ samples in the $I,Q$ plane is relatively smooth, assuming the sample time spacing $T_s$ is short compared to the correlation time $\tau_c$ of the signals, the velocity estimates form an uncorrelated sequence of random variables. This is so because to have a sufficient number of independent samples for an accurate estimate the dwell time (for data collection to make a velocity estimate) is typically much longer than $\tau_c$. Thus the radar estimates of $\overline{v(\boldsymbol{r},t)}$ are made from independent samples, and therefore form a sequence of uncorrelated random variables. Nevertheless, the ensemble average of these radar estimates (i.e., for the same instantaneous velocity field but for a different configuration of scatterers) would be equal to $\overline{v(\boldsymbol{r},t)}$. These arguments, applied to the radar estimates $\overline{v(\boldsymbol{r},t)}$, can also be applied to show that the expected value of the radar estimates of $\sigma_{\mathrm{t}}^2(t)$ is equal to the expected value of $\sigma_{\mathrm{t}}^2(t)$.

By taking the ensemble average of Eq. (10.56), substituting Eq. (10.57) into it, and noting that $<\overline{v(t)}>=0$ because steady wind has been removed, we obtain, after commuting ensemble and spatial averages,

$$<\sigma_t^2(t)>+\sigma_{\bar{v}}^2=\overline{<v^2(\boldsymbol{r},t)>}. \qquad (10.58)$$

The weighted spatial average of $<v^2(\boldsymbol{r},t)>$ is

$$\overline{<v^2(\boldsymbol{r},t)>}=\frac{\int_V <v^2(\boldsymbol{r},t)>\eta(\mathbf{r}_1)I(\mathbf{r}_0,\mathbf{r}_1)dV}{\int_V \eta(\mathbf{r}_1)I(\mathbf{r}_0,\mathbf{r}_1)dV}.$$

If turbulence is homogeneous either over the region where the weighting functions contribute significantly, or over a limited region with no turbulence outside it (e.g., homogeneous turbulence within a layer), it can be shown that $\overline{<v^2(\boldsymbol{r},t)>}=<v^2(t)>$. Substituting this latter relation into Eq. (10.58), and using Eq. (10.55), we obtain

$$\sigma_{\mathrm{P}}^2=<\sigma_{\mathrm{t}}^2(t)>+\sigma_{\bar{v}}^2=2E_r/\gamma. \qquad (10.59)$$

where $E_r=<\frac{1}{2}\gamma v^2>$ is the mean energy density of turbulence associated with the radial component of wind, and $\gamma$ is the air mass density. If turbulence is isotropic, the total turbulence energy density $E = 3E_r$. The argument '$\boldsymbol{r}$' does not appear in $\sigma_{\mathrm{p}}^2$, in contrast to that in Eq. (10.55), because we have assumed turbulence to be homogeneous. Eq. (10.59) indicates that the variance of the velocity at a point is equal to the sum of the ensemble average of $\sigma_{\mathrm{t}}^2(t)$ and the variance of the turbulent velocities weighted spatially by $I_n(\mathbf{r}_0,\mathbf{r})\eta(\mathbf{r})$, but not including the variance associated with the statistical uncertainty of the estimates of $\overline{v(\boldsymbol{r},t)}$ due to processing a finite number of weather signal samples.

This very general result requires turbulence to be locally homogeneous, although…

439 0 9 because section 11.4.1 is titled “Bragg scatter”, it is appropriate to define and use this term in this section. Therefore change this line to read: “.. to the scattered signal (i.e., Bragg scatter) occurs if..”

443 section 11.4.3 to differentiate the commonly known Bragg scatter associated with steady or deterministic perturbations from that Bragg scatter associated with random perturbations, we introduce the term “Stochastic Bragg Scatter” by replacing the second sentence of this section with:

“Perturbations in atmospheric refractive index are caused by temperature and humidity fluctuations; thus the perturbation in *n* is a random variable having a spectrum of scales. Although there is a spectrum of spatial scales, only those at about the Bragg wavelength $\Lambda_B = \lambda/[2\sin(\theta_s/2)]$ contribute significantly to the backscattered power. Because scatter is from spatial fluctuations in refractive index, the scattering mechanism is herein defined as Stochastic Bragg Scatter (SBS). Because there are temporal fluctuations as well, the scattered power is also a random variable and its properties are related to the statistical properties of the scattering medium. In this section we relate the expected…..(return to the 3rd sentence in the text)”

459 Eq. (11.124) this equation assumes that the beam width is given by Eq. (3.2b). A more general form is

$$\rho_\perp = \frac{D_a\sqrt{2}}{\pi\gamma_1}, \qquad \theta_1 = \gamma_1\frac{\lambda}{D_a}$$

4 at the end of this paragraph, “...in this section.”, add: “Under far field conditions the beamwidth part of the “resolution volume weighting” term in Eq.(11.122) does not contribute significantly to the <u>integral</u>, but beamwidth and range resolution do contribute to the backscattered power because they multiply the integral in Eq.(11.122).”

460 0 2 add the following sentence at the end of the line:
$D_h$ is the outer scale of the refractive index irregularities, but condition (11.124) applies to the transverse correlation lengths of the Bragg scatterers. Thus, the conclusion reached in this paragraph applies if the Bragg scatterer's correlation length equals the outer scale.

461 0 11 insert after "...in space.": "This is a consequence of the greater importance of the Fresnel term relative to the resolution volume weighting term (i.e., in Eq.11.122) along the transverse directions."

478 0 7 rewrite the sentence: “Then *g*, now the directional gain (section 3.1.2) is

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| | | | related to…” |
| 513 | 3 | 4 | rewrite as: “…independent of all others because the shell is assumed to be many wavelengths thick and scatterers are randomly placed in the shell. |
| 547 | Index | | add: “Antenna; far field, 435-436, 459” |
| 548 | Index | | add: “Bright band, pp. 256, 268” |
| 554 | Index | | add “Melting layer, pp. 225, 255” |
| 556 | Index | | for the entry “Radome losses” add page 43. |

**Some definitions:**

Radial: A radial is the center of a band of azimuths over which the radar beam scans during the period (i.e., the dwell time) in which a number $M$ of pulses are transmitted and echoes received and processed. $M$ echo samples at each range are processed to obtain spectral moments (e.g., reflectivity, velocity, and spectrum width) that are assigned to the center azimuth (i.e., the "radial"). A "radial of data" is usually the set of spectral moments at all the range gates (or resolution volumes) along the assigned azimuth.

**Additional errata to be reviewed by Dusan**